Physics – Uspekhi **39** (2) 206 – 207 (1996)

 PACS number: 82.40.gs, 8240.Mw, 01.30.Cc

Femtochemistry
edited by J Manz, L Wöste

Femtochemistry Vol.1 and Vol. 2 (Eds by J Manz, L Wöste) (New York, Basel, Cambridge, Tokyo: VCH, Weinheim, 1995) 916 pp

At first sight, this book should be reviewed in Uspekhi Khimii (Russian Chemical Review) rather than in Uspekhi Fizicheskikh Nauk. However, this would not be in line with the long-standing tradition here in Russia because the conventional 'borderline' between physics and chemistry is not the same for Russian and foreign readers. The area of physical research abroad is somewhat narrow as compared with how it is understood in Russia because studies on molecular and chemical physics carried out in this country are regarded by many foreign authors as belonging to chemistry. In other words, chemists in many countries make extensive use of physical methods (molecular beams, lasers, various spectroscopic techniques, etc.) which are not so widely employed in chemical research in this country. This wholly refers to femtosecond chemistry, 'the last cry of fashion' in natural sciences. Suffice it to say that two international conferences were held in Berlin (1994) and Lausanne (1995) prior to the last one in this series, the XXth Solvey Conference on "Photochemistry: Chemical Reactions and Their Control on Femtosecond Time Scale". In this context, the publication of the present two-volume monograph looks quite opportune.

The monograph consists of five parts divided into 27 chapters covering a broad spectrum of topics, from basic concepts to specific issues, reviewed by leading experts in the fields of the knowledge. Individual parts are devoted to: "Femtosecond chemistry: From flash photolysis to femtochemistry "(I), "Simple systems: Molecules" (II), "From simple to complex systems: Clusters "(III), "Complex systems: Liquids, solids, surfaces and photosynthetic reaction centres" (IV), "New directions in femtosecond chemistry: Wave-packet control and outlook" (V). It should be noted from the very beginning that the scientific level of different chapters varies. This is not surprising, for I believe that today there are hardly 27 first-class international experts in these fields of research. Nevertheless, both the publishers and the editors deserve the highest praise for their labourious efforts. It is a pity that the Mir Publishers discontinued its programme of translating such milestone books into the Russian language.

It is only natural that a brief retrospective introductory review has been written by Lord G Porter who developed the flash-photolysis technique in collaboration with M Eigen and R Norrish (they were jointly awarded the 1967 Nobel Prize in chemistry for "studies of ultrafast chemical reactions resulting from equilibrium disturbance by very short pulses of energy". In the Fifties and Sixties, this method had a time resolution at the 10^{-3} s level. Lord Porter is also the author of an interesting short chapter on "Femtosecond processes in photosynthesis". In order to clarify the situation with time resolution in chemical research, Lord Porter recalls the statement of Sir H Melville, President of the Faraday Society, made in 1947: "The direct physical methods of measurement simply can not reach these magnitudes, far less accurate measurements in a limited period of time, for example 10^{-3} s." Today, 50 years later, dynamics of chemical reactions is studied on a timescale 10^{10} times smaller, i.e. in the time interval from 10 to 100 fs.

The central chapter in the monograph entitled 'Femtochemistry: Concepts and applications' has been written by Prof. A Zewail (Caltech, Pasadena), a recognised leader in femtosecond chemistry. The editors of the monograph are quite right when they describe this chapter as 'a book in the book' (over 120 pages). The author discusses ultrafast processes (ultramolecular relaxation of energy and coherence, molecular decay, etc.) in simple di- or triatomic to complex molecules both isolated (molecular beams) and present in solutions. The chapter is concluded with a list of the most promising lines of further research, e.g. molecular electronography using picosecond electron beams, coherent control of chemical reactions, etc. This chapter is worth being translated and published in one of our scientific journals. Equally interesting is another large chapter "Molecular structures from ultrafast coherence spectroscopy" by A Zewail and P Felker of UCLA.

Other effective methods of femtosecond molecular spectroscopy are described by Dr P Sorokin et al in the chapter on "Femtosecond broadband absorption spectroscopy of fragments formed in the photodissociation of gas-phase molecules" and by Prof. J L Kinsey in the chapter "Obtaining short-time dynamics from long-time measurements in photodissociative processes". The latter author determined the shape of emission spectra for dispersed dissociation fragments which start to emit in a longer waverange as the internuclear distance between the fragments increases.

Femtosecond molecular dynamics of complex systems (clusters, Van-der-Waals complexes, clusters with *surface hydrogen bonds*) is examined in the chapters on "Femtosecond time-resolved photochemistry of molecules and metal clusters" (Prof. G Gerber), "Chemical dynamics of clusters" (Prof. J Syage), "Femtosecond intramolecular proton transfer in the condensed phase" (Prof. T Elsaesser), "Hot-electron femtochemistry at surfaces" (Prof. J Gadzuk), and some others.

Finally, new prospects in controlled chemical reactions based on the coherent evolution of wave-packets in the

Uspekhi Fizicheskikh Nauk **166** (2) 221–222 (1996)
Translated by Yu V Morozov

electronic excited state of the molecule are reviewed by prof K Wilson and co-workers in the chapter on 'Light-packet control of wave-packet dynamics'. This new intriguing field of multiphonon photochemistry makes use of the fact that the application of femtosecond laser pulses of the $\tau \ll T_2$ duration (T_2 is the time of phase memory relaxation by wave memory... or the coherence relaxation time, τ_{IVR} is the intramolecular vibrational relaxation time) provides the possibility to introduce the delay $\Delta\tau \ll T_2$, τ_{IVR} between two laser pulses during which vibrational evolution of the wave-packet ensures that the second pulse excites another region of the potential surface that can not be directly excited from the ground state because of the smallness of the Franck-Condon factors. This region may be associated with an alternative channel of the chemical reaction. Hence, the term 'coherent control of chemical reaction' to define this approach. It should be noted that this problem was a focus of discussion at the XXth Solvey Conference (December 1995, Brussels), and its solution may hopefully lead to a new break-through in laser chemistry in the near future.

It is not my intention to dwell at length on shortcomings unavoidable in such a large book of many authors. Suffice it to say that individual chapters differ in terms of scientific level and insight into the problem, some of them are not closely related to the central problem of the monograph (femtosecond photochemistry) while others look idealistic because they appear to disregard the real structure of the molecules which is quite different from that of a simple anharmonic oscillator (!), etc.

To summarise, this monograph is a valuable publication to be placed on a bookshelf under the heading "Molecular Dynamics and Femtosecond Laser Spectroscopy". I recommend Russian scientists to have a look at this shelf in a library on a visit abroad.

V S Letokhov